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Final Report of the Oak Ridge Task Force Concerning Public Health Impacts of the Off-Site Contamination in East Fork Poplar Creek and Other Area Streams

C. C. Travis
B. G. Blaylock
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R. J. McElhaney
C. W. Weber

MANAGED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

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Health and Safety Research Division

FINAL REPORT OF THE OAK RIDGE TASK FORCE CONCERNING PUBLIC HEALTH IMPACTS OF THE OFF-SITE CONTAMINATION IN EAST FORK POPLAR CREEK AND OTHER AREA STREAMS

C. C. Travis
B. G. Blaylock[1]
K. L. Daniels[2]
C. S. Gist[3]
F. O. Hoffman[1]
R. J. McElhaney[4]
C. W. Weber[4]

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1. INTRODUCTION

As a result of operations associated with the Department of Energy (DOE) facilities near Oak Ridge, Tennessee, a nearby creek, East Fork Poplar Creek (EFPC), became contaminated with mercury and trace levels of other metals, organics and radionuclides. In May, 1983, a Memorandum of Understanding was signed by the DOE, the Tennessee Department of Health and Environment (TDHE), and the U. S. Environmental Protection Agency (EPA), for the purpose of investigating the environmental contamination of EFPC. An interagency task force, identified as the Oak Ridge Task Force (ORTF) was organized to investigate the extent of off-site environmental contamination of EFPC and other area streams related to the Oak Ridge Reservation, and to determine if any immediate public health impacts might result from such contamination. Four study groups were established by the ORTF to supervise investigations of fisheries, groundwater, soils, surface water, sediment, and floodplains. A fifth study group was established to perform an evaluation of possible public health impacts. The DOE also authorized several organizations to collect and analyze samples and make field measurements needed by the Task Force. The Tennessee Valley Authority (TVA) was authorized to perform an instream contaminant study to determine the extent of contamination of surface water, sediment, fish, and floodplains. The U. S. Geological Survey (USGS) was authorized to determine the extent of groundwater contamination. Oak Ridge Associated Universities (ORAU) was charged with determining the extent of contamination of the terrestrial foodchain which might be consumed by humans. Oak Ridge National Laboratory (ORNL) was requested to provide assistance in health impact assessments.

Several studies were undertaken in the course of investigating the possible health hazards associated with EFPC contamination. Among the documents produced by these studies were an

instream water contamination study (TVA, 1985a), a sediment study (TVA, 1985b,c), a sediment screening study (Hoffman et al., 1984), a sediment transport and floodplain study (TVA, 1985d), a fish sampling study (TVA, 1985e; Travis et al., 1986), an analysis of floodplain vegetation (Gist, 1987), an instream contaminant summary (TVA, 1986), a streamflow and specific-conductance data study (U. S. Dept of the Interior, 1984), a water-quality data study, (USGS, 1985), water-quality data (USGS, 1985), streamflow and specific-conductance data (USGS, 1986),reconnaissance of surficial geology, regolith thickness, and configuration of the bedrock surface (USGS, 1986), preliminary evaluation of ground-water flow (USGS, 1988a); well construction, lithology, and geophysical logs for boreholes (USGS, 1988b), and a groundwater contamination study (USGS, 1988c). The objective of this report is to summarize the extent of off-site contamination and to provide the conclusions of the ORTF as to immediate or long-term potential health effects from such contamination.

2. HEALTH CRITERIA

The first step in identifying possible threats to human health from contaminants in EFPC was the determination of safe human exposure levels for the contaminants present. The derivation of these levels is explained in detail in Hoffman et al. (1984). Briefly, safe human exposure levels were established using criteria and data published by the EPA. For noncarcinogenic toxic chemicals, EPA values for allowable daily intakes (ADI) were used. For carcinogenic metals and organic compounds, the ADI was determined by calculating the daily intake that would result in a lifetime risk of developing cancer of 1 in 100,000. The ADI for radionuclides was determined by calculating the daily intake of a radionuclide that would result in a maximum effective dose-equivalent of 1 millirem per year. A 1 millirem dose-equivalent results in a lifetime risk of developing cancer of 1 in 100,000.

It is often convenient to have safe human exposures expressed in terms of allowable environmental concentrations rather than ADI's. For this reason, Preliminary Guidance Values (PGV's) for concentrations of pollutants in fish flesh were determined. The PGV is that concentration (mg/kg) in fish flesh that would, under normal ingestion conditions, result in an ingestion intake equal to one-third of the ADI. The factor of one-third is included to account for possible intake of the contaminant via other pathways such as water consumption and terrestrial foodchain ingestion. The PGV for fish is calculated by dividing the ADI by the product of the assumed value for the daily human fish consumption (0.02kg/d) and a factor of three. ADI's and PGV's are presented in Table 1.

3. SURFACE WATER

The purpose of the surface water study was to determine contaminant concentrations in water from selected sampling sites in EFPC, Bear Creek, White Oak Creek and the Clinch River. Samples were collected during both baseflow and storm conditions. Baseflow samples were analyzed for physical parameters, priority pollutants (organics and metals), and radionuclides. Stormflow samples were analyzed for total suspended solids, particle size, total and dissolved mercury, and radiological parameters. Six contaminants were detected at concentrations above existing standards and/or background levels.

In EFPC, total mercury concentrations are above background levels during both baseflow and stormflow conditions (TVA, 1985a). Lithium was also found at elevated levels. Cadmium, nitrates, total phenols, and tritium were found in excess of background levels in nearby streams (White Oak Creek and Bear Creek) but not in EFPC.

Table 1. Allowable Daily Intakes (ADI) and Preliminary Guidance Values (PGV) of Organics, Metals and Cyanide, and Radionuclides Used for the TVA Instream Contaminant Study

CONTAMINANT ORGANICS	ALLOWABLE DAILY INTAKE µg/d	PRELIMINARY GUIDANCE VALUES (Fish) mg/kg
ACENAPHTHENE	4.0E+1	6.7E-1
ACENAPHTHALENE	2.5E-2	4.2E-4
ACROLEIN	1.1E+2	1.8E+0
ACRYLONITRILE	3.4E-1	5.7E-3
ALDRIN	4.0E-2	6.7E-4
ALPHA-BHC	2.7E-1	4.5E-3
ALPHA-ENDOSULFAN	2.8E+2	4.7E+0
ANTHRACENE	2.5E-2	4.2E-4
BENZIDINE	4.9E-3	8.2E-5
BENZENE	3.2E+1	5.3E-1
BENZO(A)ANTHRACENE	2.5E-2	4.2E-4
BENZO(A)PYRENE	2.5E-2	4.2E-4
BENZO(GHI)PERYLENE	2.5E-2	4.2E-4
BENZO(K)FLUORANTHENE	2.5E-2	4.2E-4
BETA-BHC	4.6E-1	7.7E-3
BETA-ENDOSULFAN	2.8E+2	4.7E+0
BIS(CHLOROMETHYL)ETHER	5.0E-5	8.3E-7
BIS(2-CHLOROETHOXY)METHANE	--	--
BIS(2-CHLOROETHYL)ETHER	1.0E+0	1.7E-2
BIS(2-CHLOROISOPROPYL)ETHER	4.6E+1	7.7E-1
BIS(2-ETHYLHEXYL)PHTHALATE	4.2E+4	7.0E+2
BROMOFORM	4.0E+0	6.7E-2
BUTYLBENZYLPETHALATE	1.0E+3	1.7E+1
CARBON TETRACHLORIDE	8.6E+0	1.4E-1
CHLORDANE	1.3E-1	2.2E-3
CHLOROBENZENE	4.0E+1	6.7E-1
CHLORODIBROMOMETHANE	4.0E+0	6.7E-1
CHLOROETHANE	9.3E+5	1.6E+4
CHLOROFORM	4.8E+0	8.0E-2
CHRYSENE	2.5E-2	4.2E-4
DELTA-BHC	3.5E-1	5.8E-3
DI-N-BUTYLPHTHALATE	1.3E+4	2.2E+2
DI-N-OCTYLPHTHALATE	1.0E+3	1.7E+1
DIBENZO(AH)ANTHRACENE	2.5E-2	4.2E-4
DICHLOROBROMOMETHANE	4.0E+0	6.7E-2
DICHLORODIFLUOROMETHANE	6.0E+3	1.0E+2
DIELDRIN	3.8E-3	6.3E-5
DIETHYLPHTHALATE	4.4E+5	7.3E+3
DIMETHYLPHTHALATE	7.1E+5	1.2E+4
ENDOSULFAN SULFATE	2.8E+2	4.7E+0
ENDRIN	3.6E+1	6.0E-1
ENDRIN ALDEHYDE	7.0E+1	1.2E+0
ETHYLBENZENE	1.6E+3	2.7E+1
FLUORANTHENE	1.0E+2	1.7E+0

Table 1. (CONTINUED)

CONTAMINANT ORGANICS	ALLOWABLE DAILY INTAKE µg/d	PRELIMINARY GUIDANCE VALUES (Fish) mg/kg
FLUORENE	2.5E-1	4.2E-4
GAMMA-BHC	9.0E-1	1.5E-2
HEPTACHLOR	2.3E-2	3.8E-4
HEPTACHLOR EPOXIDE	1.9E-1	3.2E-3
HEXACHLOROBENZENE	3.0E-1	5.0E-3
HEXACHLOROBUTADIENE	1.4E+2	2.3E-1
HEXACHLOROETHANE	4.7E+1	7.8E-1
INDENO(1,2,3-CD)PYRENE	2.5E-2	4.2E-4
ISOPHORONE	1.1E+3	1.8E+1
METHYL BROMIDE	4.0E+0	6.7E-2
METHYL CHLORIDE	4.0E+0	6.7E-2
METHYLENE CHLORIDE	4.0E+0	6.7E-2
N-NITROSODIPHENYLAMINE	1.4E+2	2.3E+0
N-NITROSODI-NPROPYLAMINE	1.9E-2	3.2E-4
N-NITROSODIMETHYLAMINE	5.0E-2	8.3E-4
NAPHTHALENE	4.5E+2	7.5E+0
NITROBENZENE	4.0E+3	6.7E+1
P-CHLORO-M-CRESOL	7.9E+3	1.3E+2
PCB-1016	2.2E-1	3.7E-3
PCB-1221	2.2E-1	3.7E-3
PCB-1232	2.2E-1	3.7E-3
PCB-1242	2.2E-1	3.7E-3
PCB-1248	2.2E-1	3.7E-3
PCB-1254	2.2E-1	3.7E-3
PCB-1260	2.2E-1	3.7E-3
PENTACHLOROPHENOL	2.1E+3	3.5E+1
PHENANTHRENE	2.5E-2	4.2E-4
PHENOL	7.0E+3	1.2E+2
PHENOLS (TOTAL)	6.8E+3	1.1E+2
PYRENE	2.5E-2	4.2E-4
TETRACHLOROETHYLENE	8.1E+2	1.4E-1
TOLUENE	2.9E+4	4.8E+2
TOXAPHENE	1.6E-1	2.7E-3
TRICHLOROETHYLENE	5.7E+1	9.5E-1
TRICHLOROFLUOROMETHANE	6.4E+4	1.1E+3
VINYL CHLORIDE	1.1E+3	1.8E+1
1,1-DICHLOROETHANE	2.9E+5	4.8E+3
1,1-DICHLOROETHYLENE	2.8E+0	4.7E-2
1,1,1-TRICHLOROETHANE	3.8E+4	6.3E+2
1,1,2-TRICHLOROETHANE	5.7E+0	9.5E-2
1,1,2,2-TETRACHLOROETHANE	4.2E+0	7.0E-2
1,2-DICHLOROBENZENE	1.3E+3	2.2E+1
1,2-DICHLOROETHANE	1.5E+1	2.5E-1
1,2-DICHLOROPROPANE	4.2E+2	7.0E+0
1,2-DICHLOROPROPYLENE	1.3E+0	2.2E-2
1,2-DIPHENYLHYDRAZINE	1.0E+0	1.7E-2
1,2-TRANS-DICHLOROETHYLENE	6.7E-1	1.1E-2

Table 1. (CONTINUED)

CONTAMINANT ORGANICS	ALLOWABLE DAILY INTAKE µg/d	PRELIMINARY GUIDANCE VALUES (Fish) mg/kg
1,2,4-TRICHLOROBENZENE	2.6E+1	4.3E-1
1,3-DICHLOROBENZENE	1.3E+3	2.2E+1
1,4-DICHLOROBENZENE	1.3E+3	2.2E+1
2-CHLOROETHYLVINYL ETHER	---	---
2-CHLORONAPHTHALENE	---	---
2-CHLOROPHENOL	6.0E-1	1.0E-2
2-NITROPHENOL	1.4E+2	2.3E+0
2,4-DICHLOROPHENOL	1.0E+0	1.7E-2
2,4-DIMETHYLPHENOL	---	---
2,4-DINITROPHENOL	1.4E+2	2.3E+0
2,4-DINITROTOLUENE	1.6E+0	2.7E-2
2,4,6-TRICHLOROPHENOL	3.5E+1	5.8E-3
2,6-DINITROTOLUENE	1.6E+0	2.7E-2
3,3-DICHLOROBENZIDINE	6.5E-2	1.1E-3
3,4-BENZOFLUORANTHENE	2.5E-2	4.2E-4
4-BROMOPHENYL PHENYL ETHER	---	---
4-CHLOROPHENYL PHENYL ETHER	---	---
4-NITROPHENOL	1.4E+2	2.3E+0
4,4-DDD	2.1E+0	3.5E-2
4,4DDE	2.1E+0	3.5E-2
4,4-DDT	2.1E+0	3.5E-2
4.6-DINITRO-0-CRESOL	2.7E+1	4.5E-1

Table 1. (CONTINUED)

CONTAMINANT	ALLOWABLE DAILY INTAKE	PRELIMINARY GUIDANCE VALUES (Fish)
METALS AND CYANIDE	µg/d	mg/kg
ANTIMONY	2.9E+2	4.8E+0
ARSENIC	4.0E-2	6.7E-4
BERYLLIUM	2.0E-1	3.3E-3
CADMIUM	5.7E+1	9.5E-1
CHROMIUM	1.0E+2	1.7E+0
COPPER	2.0E+3	3.3E+1
CYANIDE	4.1E+2	6.8E+0
LEAD	1.0E+2	1.7E+0
MERCURY	2.4E+1	4.0E-1
NICKEL	2.9E+2	4.8E+0
SELENIUM	7.0E+2	1.2e+1
SILVER	1.6E+1	2.7E-1
THALLIUM	3.7E+1	6.2E-1
ZINC	1.0E+4	1.7E+2
RADIONUCLIDES	pCi/d	pCi/kg
AC-228	1.7E+3	2.8E+1
BI-212	2.4E+3	4.0E+4
BI-214	8.9E+3	1.5E+5
CO-60	2.4E+2	4.0E+3
CS-134	2.4E+1	4.0E+2
CS-137	3.3E+1	5.6E+2
K-40	1.5E+2	2.4E+3
PB-214	5.6E+3	9.7E+4
PB-212	1.5E+2	2.6E+3
PU-238	6.8E+0	1.1E-2
PU-239	6.2E+0	1.0E+2
SR-89	3.0E+2	5.1E+3
SR-90	1.9E+1	3.2E+2
TC-99	2.7E+3	4.5E+4
U-234	9.7E+0	1.6E+2
U-235	1.0E+1	1.7E+2
U-238	1.1E+0	1.8E+1

4. SEDIMENT SAMPLING AND ANALYSIS

Sediment samples were collected at sites in Bear Creek, New Hope Pond, EFPC, White Oak Lake, and Poplar Creek. The TVA analyzed these samples for more than 130 different compounds and elements, including organic materials, metals, cyanide, and radionuclides (TVA, 1985b,c). At the time these samples were collected, contaminant levels in fish had not been determined. It was therefore decided to use the measured sediment concentrations to screen for contaminants that might accumulate in fish at unacceptable levels. Screening factors were developed (Hoffman et al., 1984) which were designed to overestimate the transfer of contaminants from sediments to aquatic organisms. The pathway of exposure considered in this analysis was transfer of contaminants in sediment to aquatic organisms and subsequent ingestion of these organisms by members of the public. Because of the high levels of conservatism required by this preliminary screening analysis, contaminants identified as potentially posing a health problem could not be considered as actually violating acceptable standards established for the protection of human health. The screening methods used in this study were intended to serve only as a tool to indicate the need for futher consideration of the contaminants.

The preliminary screening analysis identified 66 organic compounds, 12 metals, and 4 radionuclides as possibly posing a potential problem through fish ingestion (Hoffman et al., 1984). These contaminants are listed in Table 2. A number of these contaminants, however, were not actually detected in sediment samples. Their concentrations were below detection limits, but the screening analysis indicated that they may pose a potential problem if they were present at the detection limit. Only 27 pollutants of the 82 contaminants identified as potential problems were actually present in concentrations in excess of their detection limits. These 27 pollutants are listed

TABLE 2. A LIST OF CONTAMINANTS WARRANTING FURTHER CONSIDERATION (EXCLUDING NEW HOPE POND STATIONS)

ORGANICS

ACENAPHTHALENE
ACENAPHTHENE
ACRYLONITRILE
ALDRIN
ALPHA-CHC
ANTHRACENE
BENZIDINE
BENZO(A)ANTHRACENE
BENZO(A)PYRENE
BENZO(GHI)PERYLENE
BENZO(K)FLUORANTHENE
BETA-BHC
BIS(2-CHLOROETHYL)ETHER
BIS(2-CHLOROISOPROPYL)ETHER
BIS(CHLOROMETHYL)ETHER
CHLORODANE
CHRYSENE
DELTA-BHC
DIBENZO(AH)ANTHRACENE
DIELDRIN
ENDRIN
ENDRIN ALDEHYDE
FLUORANTHENE
FLUORENE
GAMMA-BHC
HEPTACHLOR
HEPTACHLOR EPOXIDE
HEXACHLOROBENZENE
HEXACHLOROBUTADIENE
HEXACHLOROCYCLOPENTADIENE
HEXACHLOROETHANE
IDENO(1,2,3-CD)PYRENE
METHYLENE CHLORIDE
N-NITROSODI-N-PROPYLAMINE
N-NITROSODIMETHYLAMINE
N-NITROSODIPHENYLAMINE
NITROBENZENE
PCB-1016
PCB-1221
PCB-1232
PCB-1242
PCB-1248
PCB-1254

TABLE 2. (Continued)

ORGANICS
PCB-1260
PHENANTHRENE
PYRENE
TETRACHLOROETHYLENE
TOXAPHENE
1,2,4-TRICHLOROBENZENE
1,2-DICHLOROPROPYLENE
1,2-DIPHENYLHYDRAZINE
1,2-TRANS-DICHLOROETHYLENE
2,4,6-TRICHLOROPHENOL
2,4-DICHLOROPHENOL
2,4-DINITROPHENOL
2,4-DINITROTOLUENE
2,6-DINITROTOLUENE
2-CHLOROPHENOL
2-NITROPHENOL
3,3-CICHLOROBENZIDINE
3,4-BENZOFLUORANTHENE
4,4-DDD
4,4-DDE
4,4DDT
4,6-DINITRO-O-CRESOL
4-NITROPHENOL
METALS AND CYANIDE
ARSENIC
BERYLLIUM
CADMIUM
CHROMIUM
COPPER
LEAD
MERCURY
NICKEL
SELENIUM
SILVER
THALLIUM
ZINC
RADIONUCLIDES
CS-137
NP-237
TC-99
U-238

in Table 3. Thus the TVA sediment samples and a subsequent hypothetical analysis based on assumed transfer of contaminants in sediment to fish and subsequent ingestion of these contaminants by members of the public, identified 12 organic compounds, 11 metals, and 4 radionuclides as possibly posing a potential problem through fish ingestion (Hoffman et al., 1984). The purpose of this preliminary screening study was to ensure that contaminant levels in fish would be determined for these compounds during the TVA fish sampling study.

5. FISH SAMPLING AND ANALYSIS

The purposes of the Instream Contaminant Study (TVA, 1985a) were to determine contaminant concentrations in fish from selected sampling sites in Watts Bar and Melton Hill Reservoirs, EFPC, Bear Creek, Poplar Creek, lower White Oak Creek, and White Oak Lake; and to obtain baseline fish population data from EFPC and Bear Creek for future comparisons.

Fish samples were collected and analyzed to show the spatial delineation of contaminant levels in fish and to identify areas with the greatest potential risks to public health from the consumption of fish. Relative species abundance and species diversity in EFPC and Bear Creeks were determined. Selected aquatic organisms in EFPC (frogs, snapping turtles, and crayfish) and Bear Creek (frogs and crayfish) were also sampled and contaminant levels determined.

Fish and, in some areas, other aquatic animals (frogs, turtles, and crayfish) were collected from mid-May through June from 17 sites in Watts Bar and Melton Hill Reservoirs, White Oak Lake, White Oak Creek Embayment, EFPC, Bear Creek, and Poplar Creek (Figure 1 and Table 4.)

TABLE 3. CONTAMINANTS LISTED IN TABLE 2 WHOSE MEASURED CONCENTRATIONS IN SEDIMENT EXCEED LIMITS OF DETECTION

ORGANICS
ACENAPHTHALENE
ANTHRACENE
BENZO(A)ANTHRACENE
BENZO(A)PYRENE
BENZO(K)FLUORANTHENE
CHRYSENE
FLUORANTHENE
METHYLENE CHLORIDE
PHENANTHRENE
PYRENE
TETRACHLOROETHYLENE
3,4-BENZOFLUORANTHENE
METALS AND CYANIDE
ARSENIC
BERYLLIUM
CADMIUM
CHROMIUM
COPPER
LEAD
MERCURY
NICKEL
SELENIUM
SILVER
ZINC
RADIONUCLIDES
CS-137
NP-237
TC-99
U-238

FIGURE 1. FISH SAMPLING LOCATIONS

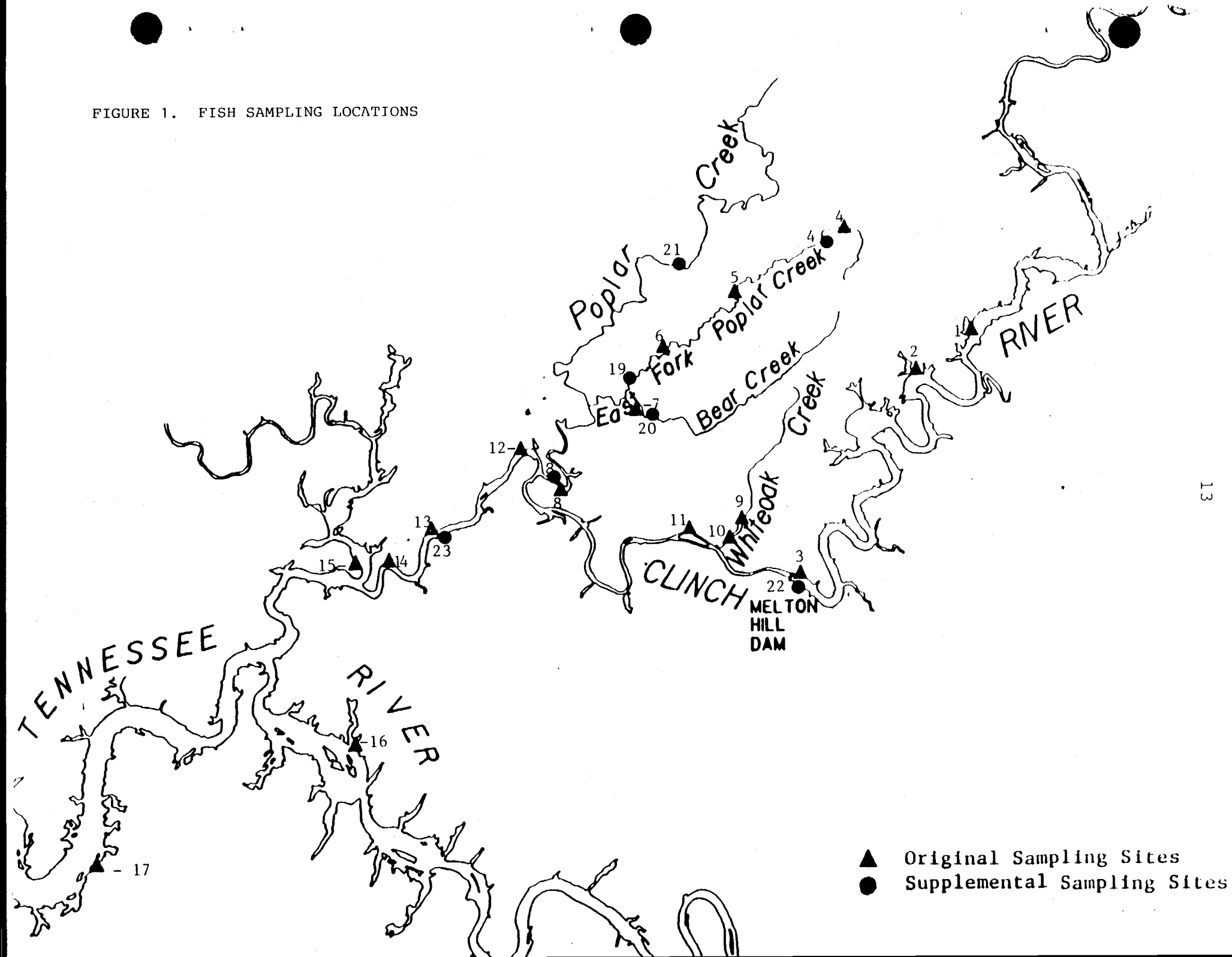

TABLE 4

INSTREAM CONTAMINANT STUDY - TASK 4
NUMBER* AND SPECIES OF FISH AND OTHER AQUATIC ANIMALS COLLECTED FOR CONTAMINANT ANALYSIS AT EACH STATION

Species	Station**																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Paddlefish																1	
Gizzard shad						1***											
Common carp				4-R	R				8-R								
White sucker						2	4-R										
Northern hog sucker						1	3										
Smallmouth buffalo								7		R		10					
Spotted sucker						1-R											
Black redhorse						1-R											
Yellow bullhead		1	4							2							
Channel catfish	10-R	9-R	3-R			1-R		10		8-R	R	10-R	10	10	10	10	10
White bass								1			R						
Yellow bass									7								
Striped bass-hybrids								3		5-R	R						
Rock bass					10-R	1	10-R										
Redbreast sunfish				10-R	10-R	2	2										
Green sunfish						1											
Warmouth						1											
Bluegill	10-R	10-R	9-R	2-R***	6	5	2	10	10-R	10-R		10-R	10	10	10	10	10
Largemouth bass	10-R	10-R	10-R	8-R				10	2-R	5	R	10-R	10	10	10	10	10
Yellow perch						1											
Sauger								2								2	
Frogs				10			1										
Snapping turtle				5	5	4											
Crayfish				C	C	C	C										

*The number given for each species and station indicates the number of individual fish samples collected for metal and organic analyses.
**Station identification by number:

1-Scarboro Creek Embayment CRM 41.2
2-McCoy Branch Embayment CRM 37.3
3-Melton Hill Dam CRM 23.5
4-EFPC Mile 13.8
5-EFPC Mile 8.8
6-EFPC Mile 4.0
7-Bear Creek Mile 0.4
8-Poplar Creek Mile 0.2
9-White Oak Lake
10-White Oak Embayment Mile 0.2
11-Clinch River Mile 20.0
12-Clinch River Mile 11.0
13-Clinch River Mile 6.0
14-Clinch River Mile 2.0
15-Emory River Mile 1.0
16-Tennessee River Mile 572.0
17-Tennessee River Mile 558.0

***Composite samples due to small size of individuals.
R - Composite radionuclide sample of 1 to 5 pounds of fillets.
C - Composite sample of whole crayfish

Due to habitat and fish population variations among sites, different fish species were sometimes used for flesh contamination analyses.

Fish flesh from the 17 sites was analyzed for 6 selected priority pollutant metals and PCBs (Table 5.) Samples from 5 of the 17 sites were analyzed for priority pollutants (i.e., 13 metals, pesticides, organic acid extractables, organic volatiles, and organic base/neutrals). Radiological analyses (including gross alpha, beta emitters, and gamma emitters) were conducted on fish from 11 sites and strontium-89 and-90 levels were measured from fish at five of these sites.

Supplemental fish samples were collected from seven sites (Table 6) from mid to late May 1984, as requested by the ORNL. These samples were analyzed for 12 priority pollutant metals and one radionuclide.

Twelve priority metal contaminants were found in quantities above the detection limit. Four of these, arsenic, beryllium, mercury, and thallium exceeded the PGV. The highest Concentration--to-PGV ratio was for arsenic (8100) followed by mercury (79). These results are given in Table 7.

The seven priority organic contaminants that were found in concentrations exceeding the detection limit are given in Table 8. Four of these organic compounds were found to be in excess of the PGV: 4,4-DDD; 4,4-DDE; Aldrin; and PCB's.

TABLE 5

INSTREAM CONTAMINANT STUDY - TASK 4
PARAMETERS ANALYZED BY SAMPLING STATION

	Station*																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Selected Metals																	
Cadmium	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x
Chromium	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x
Silver	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x
Arsenic	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x
Mercury	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x
Nickel	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x
Priority Pollutant																	
Metals	x	x		x				x		x							
PCBs	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x
Pesticides	x	x		x				x		x							
Acid extractables	x	x		x				x		x							
Volatile compounds	x	x		x				x		x							
Base/neutrals	x	x		x				x		x							
Radionuclides																	
Strontium 89 and 90				x	x				x	x		x					
Gross Alpha & Beta Emitters	x	x	x	x	x	x	x		x	x	x	x					
Gamma Emitters	x	x	x	x	x	x	x		x	x	x	x					

*Station identification by number:

1-Scarboro Creek Embayment CRM 41.2
2-McCoy Branch Embayment CRM 37.3
3-Melton Hill Dam CRM 23.5
4-EFPC Mile 13.8
5-EFPC Mile 8.8
6-EFPC Mile 4.0
7-Bear Creek Mile 0.4
8-Poplar Creek Mile 0.2
9-White Oak Lake
10-White Oak Embayment Mile 0.2
11-Clinch River Mile 20.0
12-Clinch River Mile 11.0
13-Clinch River Mile 6.0
14-Clinch River Mile 2.0
15-Emory River Mile 1.0
16-Tennessee River Mile 572.0
17-Tennessee River Mile 558.0

TABLE 6. INSTREAM CONTAMINANT STUDY - TASK 4 - LOCATIONS AND PARAMETERS FOR SUPPLEMENTAL SAMPLING STATIONS - METALS AND RADIONUCLIDE (TC99) ANALYSES OF SUNFISH AND CARP FLESH

STATION	STREAM	MILE	METALS*	TC99
19	EAST FORK POPLAR CREEK	1.7	X	X
4	EAST FORK POPLAR CREEK	13.8	X	X
20	BEAR CREEK	1.2	X	X
8	POPLAR CREEK	0.2	X	X
21	POPLAR CREEK	13.8	X	
22	CLINCH RIVER	23.5	X	
23	CLINCH RIVER	6.8	X	X

*Antimony, Arsenic, Beryllium, Cadmium, Copper, Lead, Mercury, Nickel, Selenium, Silver, Thallium, and Zinc

TABLE 7. PRIORITY METAL POLLUTANTS DETECTED IN FISH SAMPLES

METAL	MAXIMUM LEVEL FOUND MG/KG	MEAN LEVEL FOUND MG/KG	PGV MG/KG	RATIO MAXIMUM LEVEL FOUND/PGV
ANTIMONY	1.0E+0	1.0E+0	5.2E+0	1.9E-1
ARSENIC	6.0E-1	1.6E-1	7.1E-4	8.1E+3
BERYLLIUM	1.0E-1	5.2E-2	3.6E-3	2.8E+1
CADMIUM	9.4E-1	7.8E-2	1.0E+0	9.4E-1
CHROMIUM	1.0E+0	9.1E-1	1.8E+0	5.6E-1
COPPER	1.0E+1	7.6E-1	3.6E+1	2.8E-1
LEAD	1.6E+0	1.6E+0	1.8E-0	8.9E-1
MERCURY	3.3E+0	3.3E-1	4.2E-1	7.9E+1
SELENIUM	2.6E+0	5.3E-1	5.2E+0	5.0E-1
SILVER	2.0E+0	2.2E-1	1.2E+2	1.7E-1
THALLIUM	3.8E+0	1.1E+0	6.6E-1	5.8E+0
ZINC	1.7E+1	7.6E+0	1.8E+0	9.0E-1

TABLE 8. PRIORITY ORGANIC POLLUTANTS DETECTED IN FISH FLESH SAMPLES

ORGANIC COMPOUND	MAXIMUM LEVEL FOUND MG/KG	MEAN LEVEL FOUND MG/KG	PGV MG/KG	RATIO MAXIMUM LEVEL FOUND /PGV
4,4-DDD	1.0E-1	1.3E-2	3.5E-2	2.9E+0
4,4-DDE	4.0E-2	1.1E-2	3.5E-2	1.1E+0
ALDRIN	2.0E-2	1.0E-2	1.0E-2	2.0E+0
BIS(2-ETHYLHEXYL)PHTHALATE	3.3E+0	9.3E-1	7.5E+2	4.0E-4
CHLOROFORM	5.0E-2	4.9E-2	8.5E-2	5.9E-1
DI-N-BUTYL PHTHALATE	3.3E+0	9.3E-1	2.2E+2	1.5E-2
PCB'S	4.7E+0	4.3E-1	3.9E-3	1.2E+4

In addition, fish samples were analyzed for eleven radionuclides. Of these, Cs-137, K-40, Sr-90, and U-238 were found in excess of the PGV. These results are shown in Tables 9 and 10. Note that K-40 is a naturally occuring radionuclide that is not released from DOE facilities.

As a result of the fish sampling studies, the following contaminants were detected in fish flesh at concentrations that exceed the guidance values for human consumption and therefore could be considered a potential threat to human health:

4,4-DDD	4,4-DDE	Aldrin
PCB's	Arsenic	Beryllium
Mercury	Thallium	Cs-137
K-40	Sr-90	U-238

6. FLOODPLAIN VEGETATION SAMPLING AND ANALYSIS

The objective of this study was to measure the transfer of contaminants from the soils of the EFPC floodplain to vegetation that might be consumed by animals or humans. The target vegetation selected was both domestic and native. In addition, in order to complete the food chain, tissue samples from edible portions of white-tailed deer collected near the floodplain were analyzed (Gist, 1987).

The field studies were divided into two parts: native vegetation collected in contaminated areas in the EFPC floodplain, and garden vegetables grown in this floodplain.

TABLE 9. RADIONUCLIDES DETECTED IN FISH FLESH SAMPLES

RADIONUCLIDE	MAXIMUM LEVEL FOUND pCi/kg	PGV pCi/kg	RATIO MAXIMUM LEVEL /PGV
AC-228	8.0E+2	2.9E+4	2.8E-2
BI-212	9.0E+2	3.9E+4	2.3E-2
BI-214	2.6E+3	1.5E+5	1.7E-2
CO-60	1.2E+2	4.0E+3	3.0E-2
CS-134	2.7E+2	4.0E+2	6.8E-1
CS-137	2.6E+4	5.6E+2	4.6E+1
K-40	2.2E+4	2.4E+3	9.2E+0
PB-214	9.9E+2	9.7E+4	9.3E-3
SR-89	1.2E+3	5.1E+3	2.4E-1
SR-90	1.3E+3	3.2E+2	4.1E+0
TC-99	1.0E+3	4.5E+4	2.2E-2

TABLE 10. RADIONUCLIDES DETECTED IN CLINCH RIVER FISH[1]

RADIONUCLIDE	MAXIMUM LEVEL FOUND pCi/kg	PGV pCi/kg	RATIO MAXIMUM LEVEL /PGV
CO-60	2.4E+1	4.5E+3	5.3E-3
CS-137	1.3E+3	6.2E+2	2.1E+0
PU-238	4.1E-1	1.1E+2	3.7E-3
PU-239	1.5E+0	1.0E+2	1.5E-2
SR-90	9.6E+1	3.2E+2	3.0E-1
U-234	5.3E+1	1.6E+2	3.3E-1
U-235	2.5E+0	1.7E+2	1.5E-2
U-238	3.0E+1	1.8E+1	1.6E+0

[1] Data from ORNL (1985).

The native plants studied were mixed grasses dominated by Johnson Grass (Sorghum halepense), honeysuckle (Lonicera iaponica), sneeze weed (Helenium), and jewel weed (Impatiens biflora). These species were selected because of their importance in the diets of the deer and cattle which presently graze or have historically grazed or browsed on the floodplain. The plants were collected and partitioned in the field into roots, stems, leaves, and fruits when appropriate.

Vegetables were grown in contaminated soil on the floodplain in an area enclosed by a chicken-wire fence to prevent small mammals from eating the crop. The vegetables selected were beets, carrots, radishes, and spinach. These species were selected to represent both root and leaf crops. When the plants had matured, they were harvested and divided into roots and tops for each species. Soil samples were also collected at the same time and location as the vegetable samples.

During the normal course of the community sampling by ORAU, several gardens and garden vegetables were sampled. Most of these gardens were not contaminated or had low levels of mercury in the soil. Unfortunately, these samples were examined for mercury only. The results of this effort are summarized in Table 11. The average daily intake of mercury was estimated using the fraction of home grown vegetables consumed in the average household. The ratios of daily intake to allowable daily intake show that mercury concentrations in beets and radishes are of concern, although for the purpose of this calculation the daily intake (ingestion rate) of these vegetables was assumed to represent all vegetables not classified as potatoes, tomatoes, green or yellow vegetables.

A second pathway for the contaminants to reach man from the floodplain is the soil-plant-animal pathway. To examine the animal component in this chain, white-tailed deer (Odocoleus

TABLE 11. MERCURY IN VEGETATION CULTIVATED IN FLOODPLAIN SOIL

PLANT	CONCENTRATION (μg/g)	INGESTION RATE (g/d)	DOSE (μg/d)	ADI (μg/d)	RATIO (DOSE/ADI)
CARROT	3.06	1.91[1]	5.84	24	0.24
BEET	8.32	20.14[2]	167.56	24	6.98
RADISH	3.88	20.14[2]	78.14	24	3.26
ONION	0.03	20.14[2]	0.58	24	0.02
BLACKBERRY	0.002	7.43[3]	0.02	24	0.001

(1) Assume value for "all yellow vegetables" and 21.2% home grown

(2) Assume value for "all other vegetables" and 21.2% home grown

(3) Assume value for "other fruit" and 21.2% home grown
Source: USDA (1980), USEPA (1984)

virginiana) were sampled. This species was selected because it is presently the only potential meat source currently feeding on the EFPC floodplain, and the deer herd in the Oak Ridge area has been recently opened to hunting. The animals used were victims of vehicle/deer collisions on the portion of the Oak Ridge Turnpike which parallels the floodplain. Tissue samples were collected as soon as possible after the animal was killed, using care to prevent sample cross -contamination. Tissue normally eaten (liver and muscle) was collected for analysis.

The analyses of metals in deer liver and muscle are shown in Table 12. The ingestion values were calculated based on the assumption that deer meat accounted for all ingested game and that deer liver accounted for all ingested organ meats. Mercury concentrations in deer meat and liver are below levels of concern. However, routine consumption of game from the floodplain of the creek may result in an unacceptable risk from arsenic and beryllium.

7. GROUNDWATER CONTAMINATION SAMPLING AND ANALYSIS

The purpose of this study was to determine whether shallow groundwater in the vicinity of EFPC contains mercury and other contaminants originating from the Y-12 Plant (Carmichael, 1988). Sixteen shallow monitoring wells were installed at seven sites in and near the floodplain of EFPC and water-quality samples were collected to determine if contaminants found in the floodplain soil and fill are also present in the shallow groundwater. Two shallow wells were also installed at separate sites in the flood plains of small streams in the greater Knoxville area to determine background water-quality information.

TABLE 12. METALS IN DEER MUSCLE AND LIVER

METAL	SOURCE	CONCENTRATION (µg/g)	INGESTION* (g/d)	DOSE (µg/d)	ADI (µg/d)	RATIO (DOSE/ADI)
As	muscle	0.2	2.0	0.4	0.04	10.0
	liver	0.35	2.0	0.4	0.07	17.5
Ba	muscle	20	2.0	40	NA	NA
	liver	16.5	2.0	33	NA	NA
Be	muscle	<1	2.0	<2	0.2	<10
	liver	<1	2.0	<2	0.2	<10
Cd	muscle	<1	2.0	<2	57	<0.04
	liver	<1	2.0	<2	57	<0.04
Cr	muscle	2.75	2.0	5.5	100	0.06
	liver	9.9	2.0	19.8	100	0.2
Cu	muscle	6.5	2.0	13	2000	0.01
	liver	43	2.0	86	2000	0.04
Pb	muscle	<1	2.0	<2	100	0.02
	liver	2	2.0	4	100	0.04
Li	muscle	<1	2.0	<2	NA	NA
	liver	<1	2.0	<2	NA	NA
Hg	muscle	0.007	2.0	0.014	24	6E-4
	liver	0.01	2.0	0.02	24	8E-4
Ni	muscle	<1	2.0	<2	290	<0.01
	liver	<1	2.0	<2	290	<0.01
Se	muscle	<1	2.0	<2	700	<3E-3
	liver	<1	2.0	<2	700	<3E-3
Ag	muscle	0.6	2.0	1.2	16	0.08
	liver	0.55	2.0	1.1	16	0.07
Th	muscle	0.52	2.0	1.04	12.7	0.08
	liver	0.54	2.0	1.08	12.7	0.09
U	muscle	0.15	2.0	0.3	1.1	0.27
	liver	0.23	2.0	0.46	1.1	0.42
Zn	muscle	160	2.0	320	10000	0.03
	liver	135	2.0	270	10000	0.03

*Ingestion rates based on "all organ meats" and "all game".
SOURCE: USDA, 1980

Water samples collected from the monitoring wells were analyzed for a wide range of substances included on the EPA's Priority Pollutant and Superfund Contract Laboratory Hazardous Substance Lists. Unfiltered samples collected from several of the wells in the EFPC floodplain contained concentrations of antimony, chromium, lead, mercury, selenium, total phenols, and strontium-90 exceeding the maximum permissible levels specified for drinking water by the TDHE and (or) the EPA. Water from one EFPC floodplain well at a contaminated fill site contained 37 μg/L of trichloroethene, exceeding the EPA's 5.0 μg/L maximum permissible drinking-water criterion for this compound, and 8 μg/L of trans-1,2- dichloroethene, for which no drinking-water standard has been established. Organic compounds identified in EFPC flood-plain wells in low concentrations were: benzo(a)anthracene, benzo(b)fluoranthene, chrysene, 3,3'-dichlorobenzidine, di-n-butylphthalate, N-nitrosodiphenylamine, and pyrene.

Although no maximum permissible drinking-water standard has been established for uranium, concentrations of this substance exceeded the analyzing laboratory's 1.0 μg/L analytical detection limit in samples from nearly 70 percent of the EFPC flood-plain wells. Comparison of the results of total versus dissolved uranium determinations indicate that dissolved uranium comprised an average of over 75 percent of the total concentration in over 80 percent of the samples where both total and dissolved concentrations were detected.

The results of total versus dissolved trace-metal determinations indicate that, except for uranium, all trace metals identified in the samples were associated principally with suspended aquifer materials and not with the water itself. The occurrence of contaminated sediment in these samples is suspected to be the result of contaminated soil being carried down the boreholes during well installation. Therefore, with the exception of uranium, ground water in the shallow aquifer in the

vicinity of EFPC does not appear to contain trace metals in concentrations that exceed TDHE or EPA drinking-water standards. The USGS recommended additional sample collection and analysis to define the relation between suspended sediment and concentrations of organic compounds and radionuclides in the samples.

8. CONCLUSIONS

The DOE and the ORTF authorized a series of field measurements intended to characterize the extent of off-site environmental contamination of EFPC and other area streams and to determine if any immediate public health impacts might result from such contamination. The environmental studies conducted were to determine the extent of contamination in instream water, sediment and floodplains, fish, vegetation, deer, and groundwater. Environmental samples were analyzed for more than 130 different compounds and elements, including organic chemicals, metals, cyanide and radionuclides.

Surface water analysis (TVA, 1985a) indicates that total mercury and lithium concentrations were consistently above background levels in EFPC. Other contaminants found at elevated concentrations in the surrounding area (White Oak Creek and Bear Creek) were cadmium, nitrates, total phenols, and tritium.

Analysis of floodplain soil samples indicate that significant quantities of mercury resides in the upper 18 inches of the floodplain and creek channel (TVA, 1985b,c). While mercury concentrations in the floodplain generally decrease with distance downstream from the DOE facility, highly elevated levels can be found as far as four miles downstream. Due to the lack of a direct

pathway for human exposure, however, these deposits do not pose an immediate threat to human health.

The Instream Contaminant Study (TVA, 1985a) detected twelve contaminants in fish flesh (four metals, four organics, and four radionuclides) at concentrations that exceed guidance values for human consumption and therefore could be considered a potential threat to human health. Because of the high levels of conservatism used in the exposure and risk analysis, these contaminant levels could not be considered as actually violating acceptable standards established for the protection of human health. While concentrations in some individual fish samples may exceed regulatory standards, an individual would have to obtain his entire dietary fish intake from such fish in order to pose a health problem. This is an unlikely scenario. Nevertheless, EFPC was posted to discourage fishing and thereby reduce the probability of threat to human health.

Analysis of vegetation grown in contaminated soil from the floodplain identified mercury as a contaminant of concern. Mercury concentrations in deer meat and liver are below levels of concern. However, routine consumption of game from the floodplain of the creek may result in an unacceptable risk from arsenic and beryllium.

Sixteen contaminants were found in the shallow aquifer of EFPC in concentrations that could result in an unacceptable risk. However, it was the opinion of the USGS that this contamination was the result of contaminated soil being carried down the boreholes during well installation, and may not represent actual contamination of the shallow aquifer of EFPC. In addition, soluble uranium was detected in the majority of the shallow aquifer samples. Regardless, there are presently no individuals ingesting water from the shallow aquifer of EFPC.

The above studies demonstrate the existence of elevated levels of several contaminants in EFPC. While the studies indicate that contamination in EFPC is not an immediate threat to local populations, the consumption of fish and game from this area should be discouraged. Furthermore, vegetables that are intended for human consumption should not be cultivated in floodplain soil. Despite the presence of elevated levels of some contaminants, it is the opinion of the ORTF that there is no indication that EFPC or other area streams pose an immediate threat to public health or the environment.

Even though EFPC does not pose an immediate threat to public health, further investigations are necessary to determine what, if any, environmental remediation is necessary. Both Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) have specified protocols that must be followed during selection of the best alternative corrective actions. It is the recommendation of the ORTF that the federally mandated remedial alternative selection process be begun for EFPC.

REFERENCES

1. Carmichael, J. K., 1988, An investigation of shallow ground-water contamination near East Fork Poplar Creek, Oak Ridge, Tennessee, U. S. Geological Survey.

2. Gist, C. S., 1987, Soil contaminant uptake by plants in the terrestrial food chain in the floodplain of East Fork Poplar Creek, Oak Ridge Associated Unviersities.

3. Hoffman, F. O., B. G. Blaylock, C. C. Travis, K. L. Daniels, E. L. Etnier, K. E. Cowser and C. W. Weber, 1984, Preliminary screening of contaminants in sediments, ORNL/TM-9370.

4. Tennessee Valley Authority, 1985a, Instream contaminant study - Task 1, water sampling and analysis: Knoxville, Tennessee, Office of Natural Resources and Economic Development.

5. Tennessee Valley Authority, 1985b, Instream contaminant study - Task 2, Sediment characterization, V. 1: Knoxville, Tennessee, Office of Natural Resources and Economic Development.

6. Tennessee Valley Authority, 1985c, Instream contaminant study - Task 2, Sediment characterization, V. 2: Knoxville, Tennessee, Office of Natural Resources and Economic Development.

7. Tennessee Valley Authority, 1985d, Instream contaminant study - Task 3, Sediment transport: Knoxville, Tennessee, Office of Natural Resources and Economic Development.

8. Tennessee Valley Authority, 1985e, Instream contaminant study - Task 4, Fish sampling and analysis: Knoxville, Tennessee, Office of Natural Resources and Economic Development.

9. Tennessee Valley Authority, 1986, Instream contaminant study - Task 5, Summary report: Knoxville, Tennessee, Office of Natural Resources and Economic Development.

10. Travis, C. C., F. O. Hoffman, B. G. Blaylock, K. L. Daniels, C. S. Gist, and C. W. Weber, 1986. Preliminary review of TVA fish sampling and analysis report, Report of Task Group Five.

11. U. S. Department of Energy, Environmental Monitoring Report, Oak Ridge Facilities Calendar Year 1984, ORNL-6209, 1985.

12. U.S. Department of the Interior, 1984, Open-File Report 84-625, Streamflow and specific-conductance data for selected sites, February 15 through April 9, 1984, near the Y-12 Plant, the Oak Ridge Reservation, Tennessee.

13. U.S. Environmental Protection Agency, 1984, Action Level for Methyl Mercury in Fish; Availability of Compliance Policy Guide, Federal Register Vol. 49, No. 224, p. 45663, November 19, 1984.

14. U.S. Geological Survey, 1985c, Open-File Report 85-165, Water-quality data for 34 sites, April and June, 1984, near the Y-12 Plant, the Oak Ridge Reservation, Tennessee.

15. U.S. Geological Survey, 1985b, Open-File Report 85-553, Water-quality data for 35 sites, September 1984, near the Y-12 Plant, the Oak Ridge Reservation, Tennessee.

16. U.S. Geological Survey, 1986a, Open-File Report 85-68, Streamflow and specific-conductance data for Bear Creek, August 13, 1985, the Oak Ridge Reservation, Tennessee.

17. U.S. Geological Survey, 1986b, Water-Resources Investigations Report 86-4165, Reconnaissance of surficial geology, regolith thickness, and configuration of the bedrock surface in Bear Creek and Union Valleys, near Oak Ridge, Tennessee.

18. U.S. Geological Survey, 1988a, Water-Resources Investigations Report 88-4010, Preliminary evaluation of ground-water flow in Bear Creek Valley, the Oak Ridge Reservation, Tennessee.

19. U.S. Geological Survey, 1988b, Water-Resources Investigations Report 88-4068, Well construction, lithology, and geophysical logs for boreholes in Bear Creek Valley near Oak Ridge, Tennessee.

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